THE RELATIONSHIPS OF THE TYROGLYPHOID MITE, HISTIOSTOMA POLYPORI (OUD.) WITH THE EARWIG, FORFICULA AURICULARIA LINN.

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Introduction

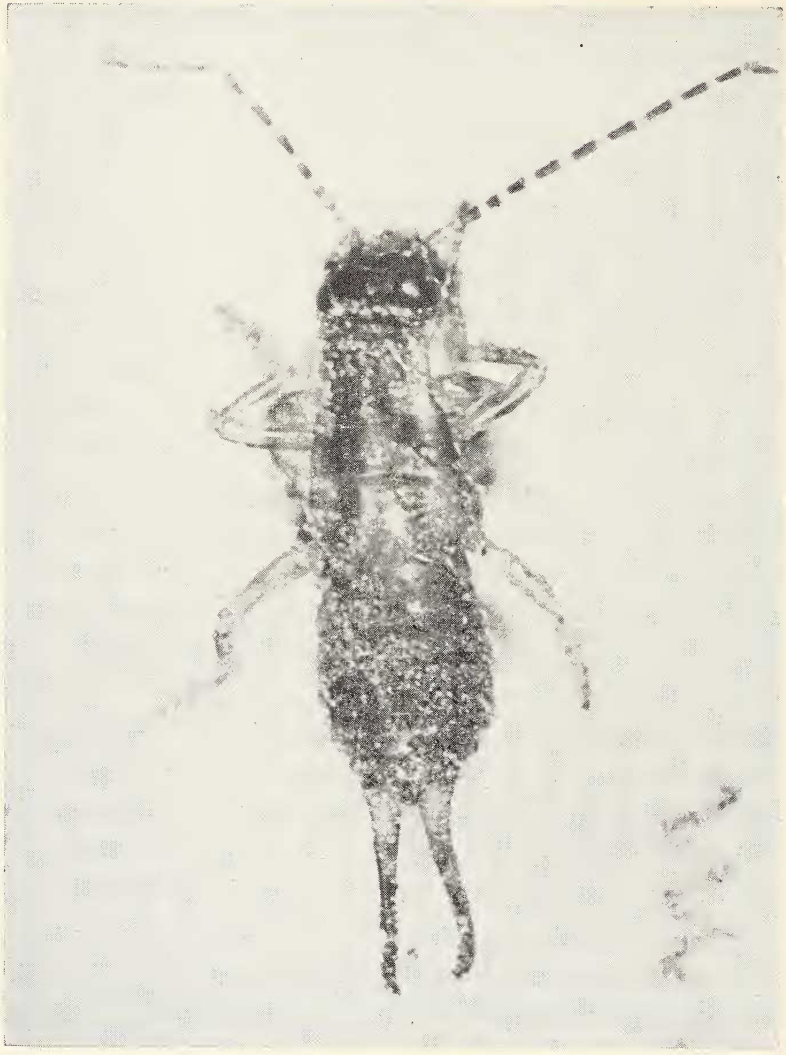
Insects are often infected with mites which do not assume a parasitic role. These mites represent that peculiar stage in the life cycle of members of Tyroglyphoidea, known as the "hypopus" stage. The hypopial phase in the life cycle of the Tyroglyphoid mite is regarded as a typical adaptation for resisting adverse conditions such as scarcity of food and a dry climate, involving a high temperature and a low humidity (Vitzthum, 1932; Solomon, 1943; Hughes, 1948). They are also regarded as a dispersal phase, because they cling to animals and are carried from one place to another. Specimens of the common European earwig, *Forficula auricularia* L., taken from the field in Edinburgh, Scotland were often found to be heavily infected with the hypopi of *Histiostoma polypori* (Oud.). It was assumed that the mobile hypopi, as in other cases, were merely riders on *Forficula*. During my investigations on the life-history of *H. polypori* and *F. auricularia*, I discovered that the association of the hypopus with *Forficula* was of greater significance in the life-cycle of the mite than had hitherto been suspected, a preliminary note about which was published earlier (Behura, 1950).

The role of the hypopus of H. polypori

The hypopus of *H. polypori* (Text-fig. 1) attaches itself to the body of the earwig, not only for the purpose of transportation; but also for the vital purpose of indirectly obtaining its food for the propagation of its species. Sometimes owing to sheer numbers, the hypopi interfere with the feeding and locomotory parts of the earwig (Plate 1) and initiate its early death.

The hypopi attached to the larvae or adults of *Forficula* did not return to the soil at random, but only dropped off if they

(JOUR. N.Y. ENT. SOC.), VOL. LXIV (PLATE I)



Heavy infection of hypopi of *Histiostoma polypori* (Oud.) on the larva of *Forficula auricularia* Linn.

were carried to a favourable situation. The hypopi usually remained attached to the earwig until it died. It is clear that the decomposing state of the dead tissues and exudation of liquified material induces the transformation of the hypopus to the deutonymph. The deutonymphs fed on the liquefied remains and soon changed into adults which laid eggs in and around the periphery of the available food. A colony of mites was soon established and according to the conditions a varying number of hypopi were again produced.

ATTACHMENT AND POSTURE ON THE BODY OF FORFICULA

The earwigs probably accumulate mites during their nocturnal expeditions. The region of heaviest infection is upon the underside of the head. However, when the infection is heavy, they are also thickly scattered over the dorsal and ventral sides of the body, the antennae and legs (Plate 1).

The hypopi cling to the smooth cuticular surface of the body of the earwig by means of their ventral battery of suckers (Text-fig. 1 B). They cling so tenaciously to the smooth surface that it is extremely difficult to detach them. In the resting position, the anterior two pairs of legs of the hypopus are directed forward, and close together, while the two poorly developed posterior pairs are hidden beneath the body.

The hypopi on the body always face in the opposite direction to that in which the earwig is moving. On the head, the positions of the hypopi are somewhat irregular. On the leg, the hypopi face the distal portion of the joints and they are arranged along the long axis of the joints. On the abdomen the hypopi are arranged in transverse rows on the chitinous plates of the abdomen. This distribution of hypopi on the abdomen is particularly well-marked when the infestation is not too heavy. This orientation of the body with the posterior part of the hypopus facing the direction of movement, presents a streamlined surface which lessens friction and protects the appendages as the earwig moves into crevices. The hypopi are also arranged symmetrically; thus, the balance of the earwig is maintained.

Similar observations have been recorded by Wasmann (1892) on the orientation of hypopi of *Tyroglyphus wasmanni* Moniez on the legs of ants, although he did not apparently discover any

special type of orientation in the other infested parts of the body namely the head, thorax and abdomen. Michael (1901) did not discover any regularity of position of hypopi of *Histiostoma rostroserratum* Mégnin on ants, which were noticed in

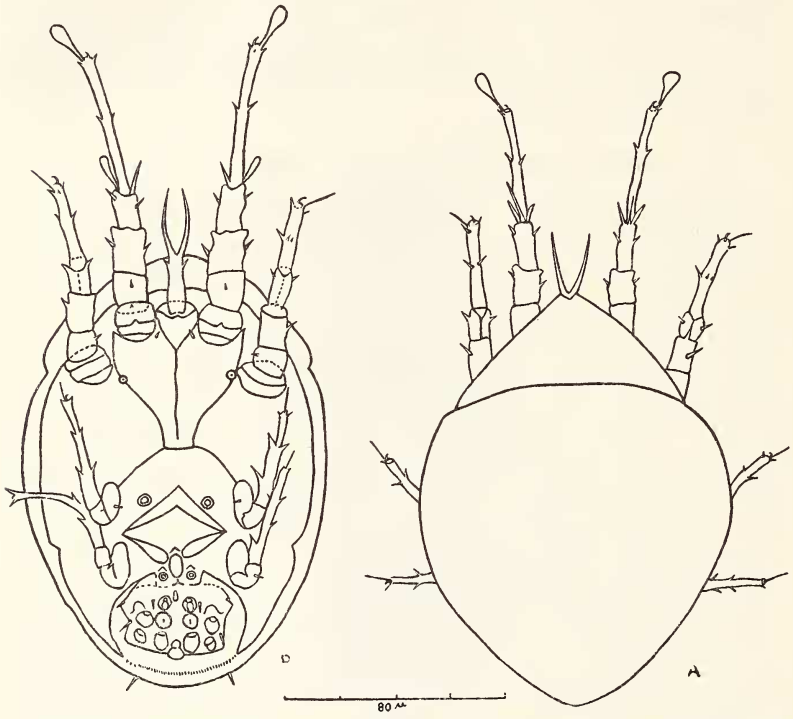


Figure 1. *Histiostoma polypori* (Oud.). Hypopus. A, Dorsal view; B, Ventral view.

crowded masses, especially on the head. However, Janet's (1897) observations on the orientation of a widely different group of Acarina, viz.: the Gamasidae, merits mention. He found that *Antennophorus uhlmanni* Haller and *Cilliba* (*Discopoma*) *comata* Leonardi when found upon the ant *Lasius mixtus* arranged themselves either bisymmetrically or in the median line so as not to upset the balance of the host that carried them. The *Antennophorus* have their anterior ends directed forward when they are on, or rather under the head of the ant, and backward on its abdomen.

MOVEMENT AND MOULTING RELATIONSHIP

The anterior legs of the hypopus are very long (about 101 μ) in comparison to the length of the body (158μ to 179μ). Although they are capable of crawling somewhat rapidly, their long tarsi serve primarily as tactile organs. When they have been given the opportunity of attaching themselves to the earwig they will then move to a suitable habitat. Their movements are unbalanced and cautious. The earwig responds to the movements of the hypopi over the body by rubbing its legs against the body. While crawling, the hypopus completely rests on its legs and in spite of the caroncle or sucker at the top of the first tarsi, they will lose their hold easily if the host is suddenly jerked. On one occasion, a hypopus was removed by a *Forficula* larva from the tarsus as the mite was crawling upward towards the thorax and then devoured.

If the conditions of food and moisture are not favorable the hypopi will remain attached to the same individual earwig from the larva to the adult stage. The hypopi are arranged over the general surface of the body of the active stages. Ecdysis in *Forficula* begins by the splitting of the old skin in the region of the thorax. Before this takes place the hypopi will move toward this region and migrate from the old cuticle to the newly formed cuticle of the next stage. After each fresh moult of the earwig larva, the hypopi are found aggregated in the groove between the head and thorax of the host. When the hypopi as an arranged mass have established themselves on the new cuticle of the next stage they radiate to different parts of the body and orientate themselves into the position previously described.

SENSORY PERCEPTION OF THE HYPOPUS

The synchronisation of hypopial migration on *Forficula* with the moulting process, in itself, merits a special consideration of the sensory perceptions of the hypopus. It is generally known that the active hypopus is highly sensitive to touch. Hence it appears that its whole body acts as some sort of dynamic perceptor organ (Michael, 1901). The perception of the pre-moulting phase of the host by the hypopus is difficult to explain. It is a problem beyond the scope of this present work. But judging from my own observations, this peculiar migration suggests

the possibility of the hypopus being able to detect some chemical changes during the pre-moulting phase. It is well known that the waxy secretion coating the surface of the cuticle of the earwig is continuously renewed. The secretions produced by the hypodermis exude from the vertical canals which pierce the cuticle. As a prelude to moulting these secretions will stop because the old cuticle will be separated by the moulting fluid from the new cuticle and hypodermis. It is suggested that this stoppage of the chemical substance detected by the attached hypopus is a stimulus which induces movement. The nature of this stoppage and how it would govern the direction of movement is a separate problem. The setae of the legs are tactile in function. There are two long setae borne on a small basal sclerite representing the non-functional mouth. The leaf-like structures on the tarsi of the legs more closely resemble possible chemo-receptor end organs. Their form and texture are similar to the thin-walled sensory end organs of insects which are credited with this function (Wigglesworth, 1947).

THE RELATIONSHIPS BETWEEN H. POLYPORI AND F. AURICULARIA IN THE NATURAL ENVIRONMENT

Following the investigations in the laboratory and the observations in the field it seemed desirable to consider the relationships between the Anoetid, *H. polypori* and *F. auricularia* in the natural environment.

The availability of freshly decayed vegetable and animal matter, the higher temperatures and humidities during the summer provide the most favourable conditions for the propagation of *H. polypori.* It is during this time that *F. auricularia* exhibit the gregarious habit when both adults and late brood larvae live together in large colonies of about 500–600 (Weyrauch, 1929). Towards the end of the summer the drier climate leads to the formation of hypopi of *H. polypori* in larger numbers. The mites are given the opportunity of climbing onto the earwigs as they forage over the surface of the soil and low-lying vegetation during darkness. The agile hypopi with their well developed tactile sense will experience no difficulty in climbing onto the earwig as it moves with the ventral surface closely applied to the soil. Earwigs collected during summer months are usually heavily infested

with hypopi, because, apart from the dry conditions, the gregarious habits of *Forficula* afford suitable opportunities for the hypopi to climb onto different individuals which will later transport them to the separate nests.

The advent of winter breaks up the colonies into separate pairs of males and females which hibernate for the winter (Behura, 1950a). Towards the end of the winter, the female earwig begins laying her first brood of eggs and she ejects the male from the nest. The males either remain outside the nests as single individuals or they may aggregate together in small groups. Before the onset of spring the majority of the males have succumbed to the unfavourable winter conditions. The hypopi which have attached themselves to the males will thus be rewarded by the early death of this sex but the increase in the size of the colony feeding on the dead male earwig in winter is a slow process owing to the retarding effect of the low temperature upon the life-cycle. The dry cold conditions also result in the production of greater numbers of hypopi within the colony. The hypopi attached to the females do not obtain the same opportunity of starting winter colonies.

In the early spring the overwintering female lays the first batch of eggs and some of the hypopi still attached to the females are given the opportunity of transferring themselves to the earwig larvae. The female and somewhat advanced larvae forage at night towards the late spring and hypopi, which have originated from winter colonies of mites formed on dead male earwigs, will be given the opportunity of attaching themselves to the old females and the larvae. The old female will either die at this stage or retreat to her cell to lay a second batch of eggs (Behura, 1950a). The death of the female will naturally provide suitable conditions which will induce the hypopi to change to deutonymphs. The nymphs will feed on the decomposing remains and change to adults resulting in the production of succeeding generations, all thriving within the colony. As the decomposing soft parts dehydrate and only the exoskeletal parts remain, there is an increase of hypopi within the colony.

The *Forficula* larvae produced from the first and second broods become infested with hypopi which have originated either from winter colonies or from spring or early summer colonies formed upon the remains of dead female earwigs.

Hence the overwintering female is also responsible for providing overwintering hypopi with a suitable attachment protected by the favourable conditions of the earthen cell. The survival rate of hypopi produced by winter colonies feeding on dead male earwigs is difficult to estimate. Although the hypopi are designed for existing at a low rate of metabolism there was no real evidence from the results of laboratory tests that their survival rate at very low temperatures was very much higher than the normal forms.

It is therefore clear that a form of synchronised behaviour exists in the relationship of *H. polypori* and *F. auricularia* which is beneficial to the mite other than that of a means of distribution. Attachment of hypopi to the overwintering female earwig protected by her cell, ensures the survival of the species of mite, since the female earwig will in the following early summer die and provide the attached hypopi with conditions ideal for the production of a large colony of mites.

It was also clear that mite colonies were not dependent on decomposing animal remains since they were capable of thriving on moist filter paper. In such cases the mites were probably feeding on a fungus. In the normal environment the mites would therefore feed and multiply upon nutrient substances other than decomposing animal remains. But the fact that the mites are able to feed and thrive upon fungi or decayed vegetation does not itself make them independent of *Forficula.* If, as was previously thought, the hypopi merely dropped at random from the earwig onto the soil after being transported for a variable distance they would frequently drop onto unfavourable soil. The mites are dependent for survival on moist conditions and large colonies will thrive best only when the substratum is saturated with moisture.

The answer to this close relationship therefore lies in the preference of both *H. polypori* and *F. auricularia* for a moist micro-climate. The micro-climate favoured by *Forficula* is ideal for the production of mites. It was also noticeable in the laboratory tests that the hypopi were sensitive to changes in humidity and very moist conditions alone would sometimes induce them to change to normal nymphs. Thus the persistent nature of the attachment of the hypopi to *Forficula* is understandable since the hypopi would be induced to move or change to normal

nymphs, only when the moist decomposing soft parts of the dead earwig are made available.

The association is also beneficial to the mite because the earwig, apart from considerable lateral movement on the soil surface, will always select a moist habitat in which to settle. Such habitat also favour the growth of fungi and the presence of decaying vegetation, both suitable as food requirements of the mite.

The attachment of hypopi of *H. polypori* to *F. auricularia* in the natural environment is therefore something more complex and more integrated than the previous assumption that the hypopi are merely picked up and transported for various distances by the earwig as it forages over the surface of the soil and lowlying vegetation.

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SUMMARY

Forficula auricularia Linn., is often found infected by the hypopi of *Histiostoma polypori* (Oud.). They arrange themselves with their streamlined posterior surface facing the direction in which the earwig is moving. They also arrange themselves symmetrically so that the balance of the earwig is maintained. The hypopus apart from being the distribution phase will remain attached to the earwig until it is either transported to a favourable habitat or until the earwig dies. Hypopi clinging to nymphs of *F. auricularia* migrated to the new cuticle of the moulting earwig and so remained attached to the host until it attained the adult condition and eventually died; its decomposing remains then furnished food for different stages of the mite.

It is suggested that the hypopus, besides possessing a well developed tactile sense, is capable of detecting chemical changes upon the surface of the cuticle.

The relationship between *H. polypori* and *F. auricularia* in the natural environment is discussed.

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(Items marked with an asterisk (*) were not available to the author in original.)

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(*Continued from page 84*)

and the entertaining of Dr. Petr Wygodzinsky, hemipterist from Tucuman, Argentina, during July. Dr. Ruckes also reported on a swarm of *Megarhyssa lunator* which were observed ovipositing in an old maple infested with *Tremex*. Apparently the female at first holds the ovipositor parallel to the tree's surface and finding the proper place for insertion applies the tip of the ovipositor to that point then slowly backs up so that the ovipositor gradually takes on a vertical position and finally assumes the typical "?" form so often represented in illustrations of the species.

President Vishniac also commented on the peculiar habits of this wasp. He then proceeded to show slides in color of his trip to the Gulf of Mexico and some of the biology encountered there.

(*Continued on page 98*)